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THE NOISE ENVIRONMENT OF A SCHOOL CLASSROOM DUE TO THE OPERATION OF UTILITY HELICOPTERS

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16. Abstract

Noise measurements under controlled conditions have been made inside and outside of a school building during flyover operations of four different helicopters. The helicopters utilized for this series of tests were the Bell 204, 206, and 47 and the Hughes 269. This group of helicopters included both turbine and reciprocating engine-powered aircraft. The helicopters were operated at a condition considered typical for a police patrol mission. Flyovers were made at an altitude of 500 ft and an airspeed of 45 miles per hour. During these operations acoustic measurements were made inside and outside of the school building with the windows closed and then open.

The outside noise measurements during helicopter flyovers indicate that the outside dB(A) levels were approximately the same for all test helicopters. For the windows closed case, significant reductions for the inside measured dB(A) values were noted for all overflights. These reductions were approximately 20 dB(A); similar reductions were noted in other subjective measuring units. The measured internal dB(A) levels with the windows open exceeded published classroom noise criteria values; however, for the windows-closed case they are in general agreement with the criteria values.

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SUMMARY

Noise measurements under controlled conditions have been made inside and outside of a school building during flyover operations of four different helicopters. The helicopters utilized for this series of tests were the Bell 204, 206, and 47 and the Hughes 269. This group of helicopters included both turbine and reciprocating engine-powered aircraft. The helicopters were operated at a condition considered typical for a police patrol mission. Flyovers were made at an altitude of 500 feet and an airspeed of 45 miles per hour. During these operations acoustic measurements were made inside and outside of the school building with the windows closed and then open.

The outside noise measurements during helicopter flyovers indicate that the outside dB(A) levels were approximately the same for all test helicopters. For the windows closed case, significant reductions for the inside measured dB(A) values were noted for all overflights. These reductions were approximately 20 dB(A); similar reductions were noted in other subjective measuring units. The measured internal dB(A) levels with the windows open exceeded published classroom noise criteria values; however, for the windows-closed case they are in general agreement with the criteria values.

INTRODUCTION

Municipal governments and other agencies are utilizing light utility-type helicopters for police operations and other activities. These activities normally require that the helicopters involved be operated over populated areas at relatively low altitudes and low speeds for extended periods of time. Recent government programs have made certain types of surplus military helicopters available to municipalities at very reasonable costs. These programs are sure to result in more helicopters of this type in operation over populated areas. Concern has been voiced as to the effects of the operation of these helicopters on the interior noise environments of such institutional facilities as schools, hospitals, etc. Data exist concerning the externally radiated noise signatures of some of these aircraft (ref. 1); however, very little data exist concerning the internal noise environments of buildings due to the overflight of various helicopters under controlled conditions.

The purpose of this paper is to present noise measurements that were made under controlled conditions both inside and outside of a school building during flyover operations of four different types of helicopters. Internal noise data

were collected with the windows open and with the windows closed. The objective of the measurement program was to assess the effect of rotorcraft noise on the internal noise environment of a selected school building. Presented in the paper are brief descriptions of the helicopters utilized for the tests, the operational procedures, and representative noise data including 1/3 octave band spectra, dB(A) time histories, average dB(A) values, and listings of other selected noise rating units. The results are compared to generally accepted classroom dB(A) criteria (ref. 2).

TEST VEHICLES

The helicopters utilized for this series of tests were the Bell 204, Bell 206, Bell 47, and the Hughes 269. Photographs of these vehicles are shown in figure 1. Both turbine and reciprocating engine-powered aircraft are included, with gross weights ranging from approximately 1600 lbs to approximately 8500 lbs. The principal noise sources for each aircraft are indicated in figure 2, and are seen to be the engine, main rotor, and tail rotor.

TEST SITE AND AIRCRAFT FLIGHT OPERATIONS

The building chosen for these tests was the high school classroom building of the Norfolk Christian School System located in Norfolk, Virginia. It is a two-story building constructed of brick and cinder block with the outside wall of each classroom being made up of jalousy-type windows. An aerial veiw of this school is shown in figure 3. Outside acoustic measurements were taken in the parking lot and on the roof of the building as indicated in the figure. Internal measurements were taken in the middle of an unoccupied classroom as indicated in the inset photograph.

A representative police patrol mission profile was chosen for the helicopter flight operations. Repeated straight and level flyovers were made on a flight track as indicated in the figure at an altitude of 500 ft and a forward speed of 45 mph. As indicated by the flight track arrow in the figure, data passes were always made from the front to the rear of the building. During the tests, there were no large variations in the surface weather conditions; temperatures varying from 50°F to 69°F, relative humidity from 55 percent to 42 percent, and wind speeds varied from 3 mph to 9 mph.

INSTRUMENTATION

The microphones and recording systems utilized for these tests were commercially available B&K 1/2 in. microphones and following equipment whose outputs were recorded on a 7-track FM magnetic tape recorder having a flat response from 0 to approximately 12 kHz. The outside microphones were placed on a 1.2 meter stand with the diaphragms parallel to the vertical plane of the flight track. Wind screens were utilized at all times on all microphones.

The inside microphones were also mounted on a 1.2 meter stand and were selected for best random incidence response. The microphone and following systems were calibrated in the field by use of a standard discrete frequency acoustic calibrator that produced a sound pressure level at the microphone diaphragm of 114 dB rms, referenced to 0.0002 dynes/cm^2 at a frequency of 1.0 kHz.

WINDOW WALL CHARACTERISTICS

In an attempt to gain some insight as to the characteristics of the window wall of the test classroom, a noise reduction experiment was accomplished and the results of this study are shown in figure 4. Two speaker systems complete with amplifiers and source generators were located approximately 15 ft from the windows of a first-floor classroom. Microphones were located outside the windows and in the center of the test classroom. Several noises were used including sine sweeps, random and pink noise; and the average results are presented in the figure. The measured noise reductions show increasing values with increasing frequency. For comparative purposes the noise reduction ranges of many residential type structures (ref. 3), are also indicated in the figure, and it is seen that the results from the present study agree in general with the reference data for residences.

MEASURED FLYOVER NOISE

The total results of the program are presented in summary form for selected units of measure for all helicopters and test conditions. Presented in figure 5 are typical 1/3 octave spectra as measured during the overflights of the Bell 206 helicopter. These data are for one flight and show the spectra that occurred at the maximum overall sound pressure level as measured outdoors and in the classroom with the windows open and the windows closed. The outdoor spectrum was typical of that for all of the test vehicles; exhibiting peaks at the main and tail rotor fundamental and harmonic frequencies. For the windows closed case, significant reductions throughout the entire frequency range are realized particularly at the higher frequencies. These results would be expected from the data of figure 4. Lesser noise reductions are noted for the windows-open case.

Utilizing spectral data of the type illustrated in figure 5, dB(A) values for each noise measurement have been derived. Examples of dB(A) time histories are presented in figure 6 for the Bell 206. Data are shown for an external measurement and internal measurements with the windows open and the windows closed. It can be noted that the internal dB(A) time history with the windows open is essentially the same shape as the external signature but is on the order of 4 to 5 dB(A) lower. For the windows-closed case, the onset of the internal dB(A) time history is similar to the one measured outside but the decay rate is different. Also, there is a significant reduction noted between max dB(A) value as measured outside and the maximum inside windows-closed

dB(A) value. Indicated in the figure is the inside ambient level of approximately 43 dB(A) measured with the windows closed.

COMPARISON OF INSIDE/OUTSIDE NOISE LEVELS

Presented in figure 7 are the average maximum dB(A) values for the test helicopters including outside data and inside data (windows open and windows closed). Also shown is an accepted criterion concerning dB(A) levels for a school noise environment (ref. 2). From this figure it can be seen that the maximum outside dB(A) levels for all four helicopters are similar, all being in the 78-82 dB(A) range. For the windows open case, moderate reductions on the order of 1 to 6 dB(A) are noted; however, more substantial reductions in the dB(A) values are noted with the windows closed. The least reduction is noted for the Bell 204 helicopter which produces very strong main and tail rotor rotational harmonics at higher frequencies. For the windows-closed situation, the internal dB(A)'s were in general conformity with published criterion for activity rooms and classrooms. For the windows-open situation the levels exceeded the criteria values.

Other measurement units are presented in tabular form in figure 8. Listed are overall sound pressure levels, EPNL, dB(A), and PSIL for all helicopters and all test conditions. These results show the same general trend as previously illustrated, that is, larger noise reductions are noted for the window closed case.

CONCLUDING REMARKS

Noise measurements under controlled conditions have been made inside and outside of a school building during flyover operations of four different helicopters. The helicopters used for this test were the Bell 204, 206, and 47 and the Hughes 269. This group of helicopters included both turbine and reciprocating engine-powered aircraft. The helicopters were operated at conditions considered typical for a police patrol mission. Flyovers were made at an altitude of 500 ft and an airspeed of 45 miles per hour. During these operations acoustic measurements were made inside and outside of the school building with the windows closed and then open.

The outside noise measurements during helicopter flyovers indicate that the maximum outside dB(A) levels were approximately the same for all test helicopters. For the windows closed case, significant reductions for the inside measured dB(A) values were noted for all overflights. These reductions were approximately 20 dB(A); similar reductions were noted in other subjective measuring units. The measured internal dB(A) levels with the windows open exceeded published classroom noise criteria values; however, for the windows-closed case they are in general agreement with the criteria values.

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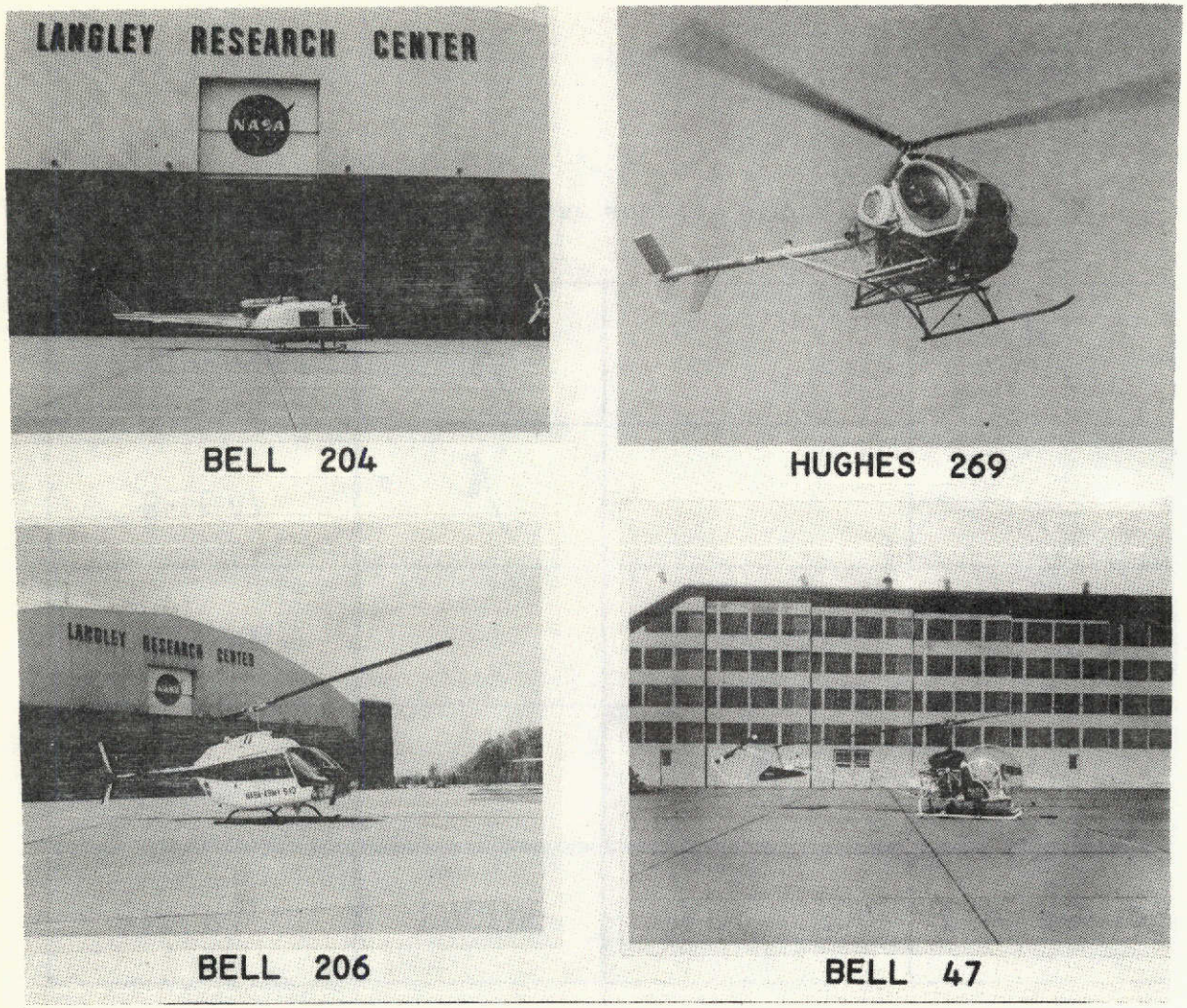

Figure 1.- Photographs of helicopters of the type used during tests.

AIRCRAFT	ENGINE	MAIN ROTOR	TAIL ROTOR
BELL 204		√	
BELL 206			√
BELL 47	√		
HUGHES 269	√		√

Figure 2. - Principal noise sources of the test aircraft.

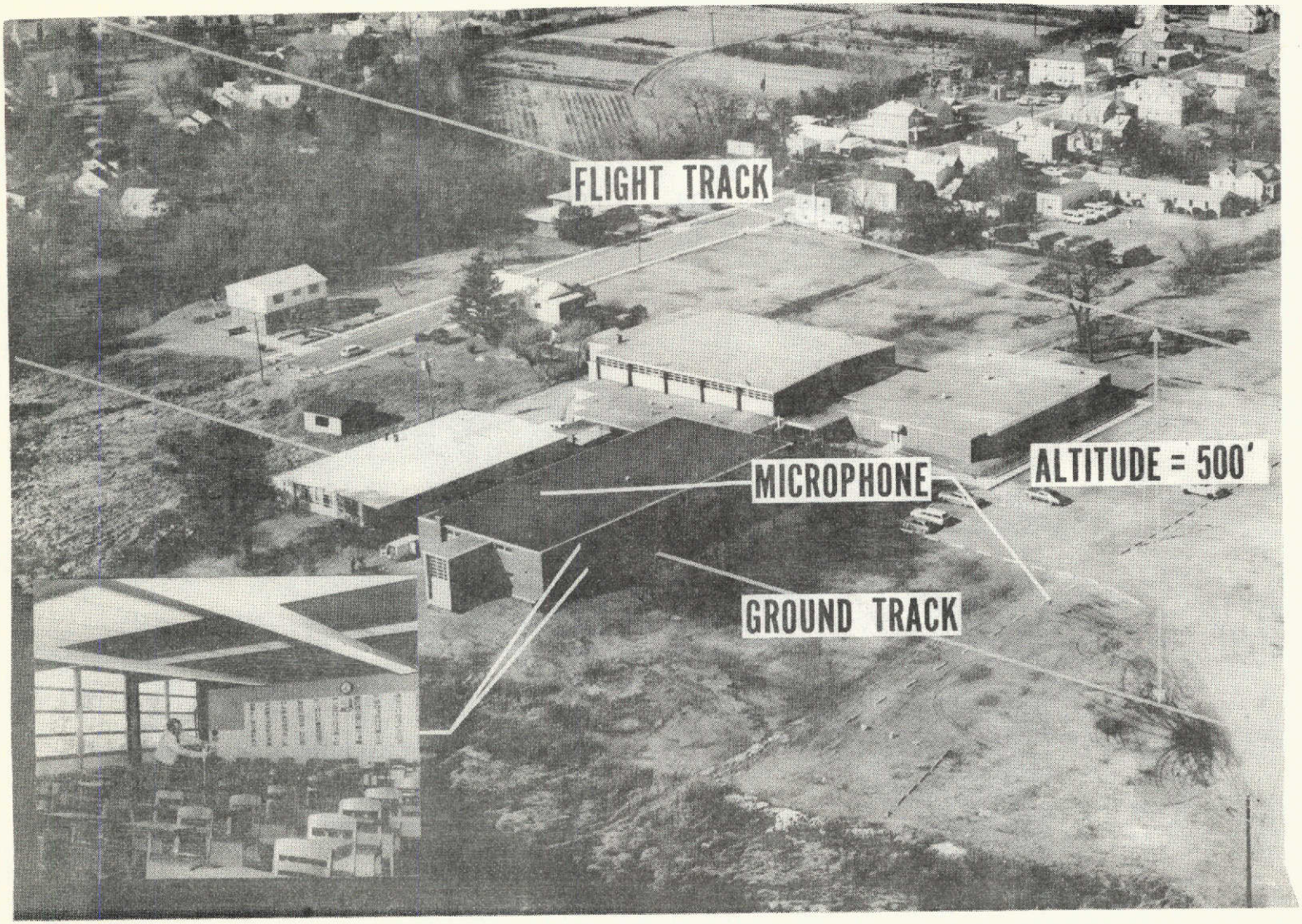

Figure 3. - Photograph of test building with indications of flight track and microphone locations.

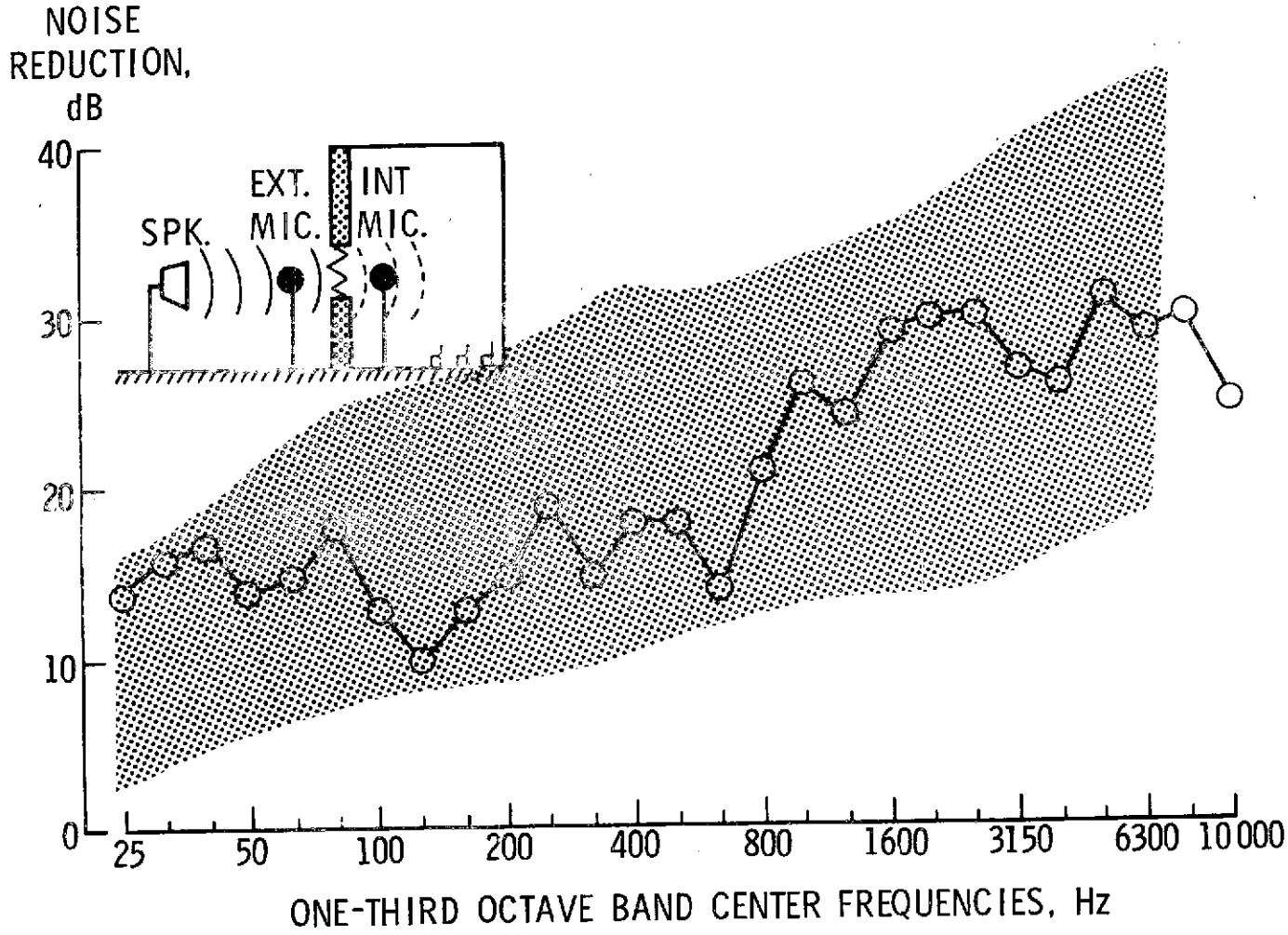

Figure 4. - Noise reduction characteristics of the classroom windows and wall structure.

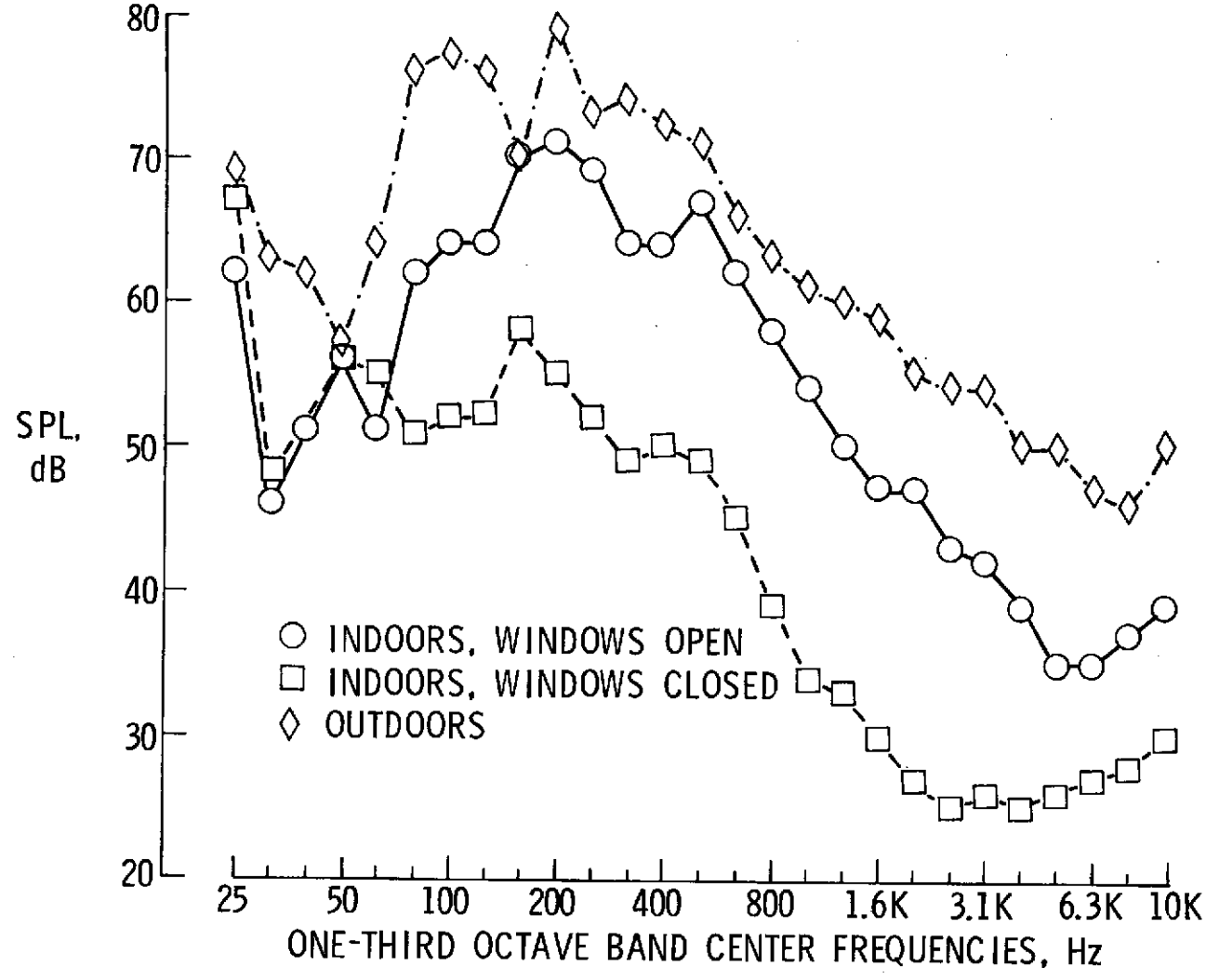

Figure 5. - Representative noise spectra as measured inside and outside of the test classroom during overflight of the Bell 206 Helicopter.

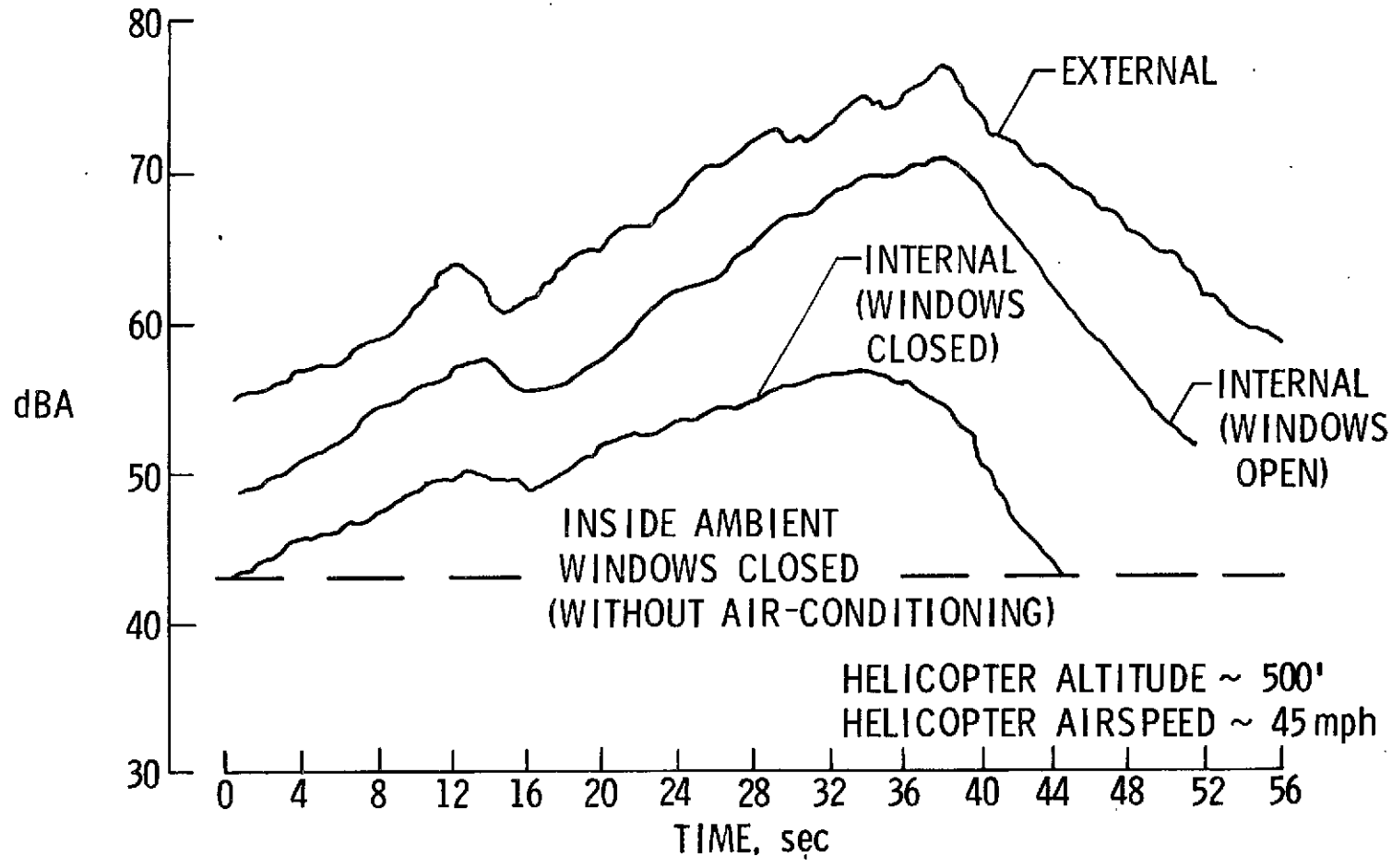

Figure 6.- Typical dBA time histories measured during the flyover of the Bell 206 Helicopter.

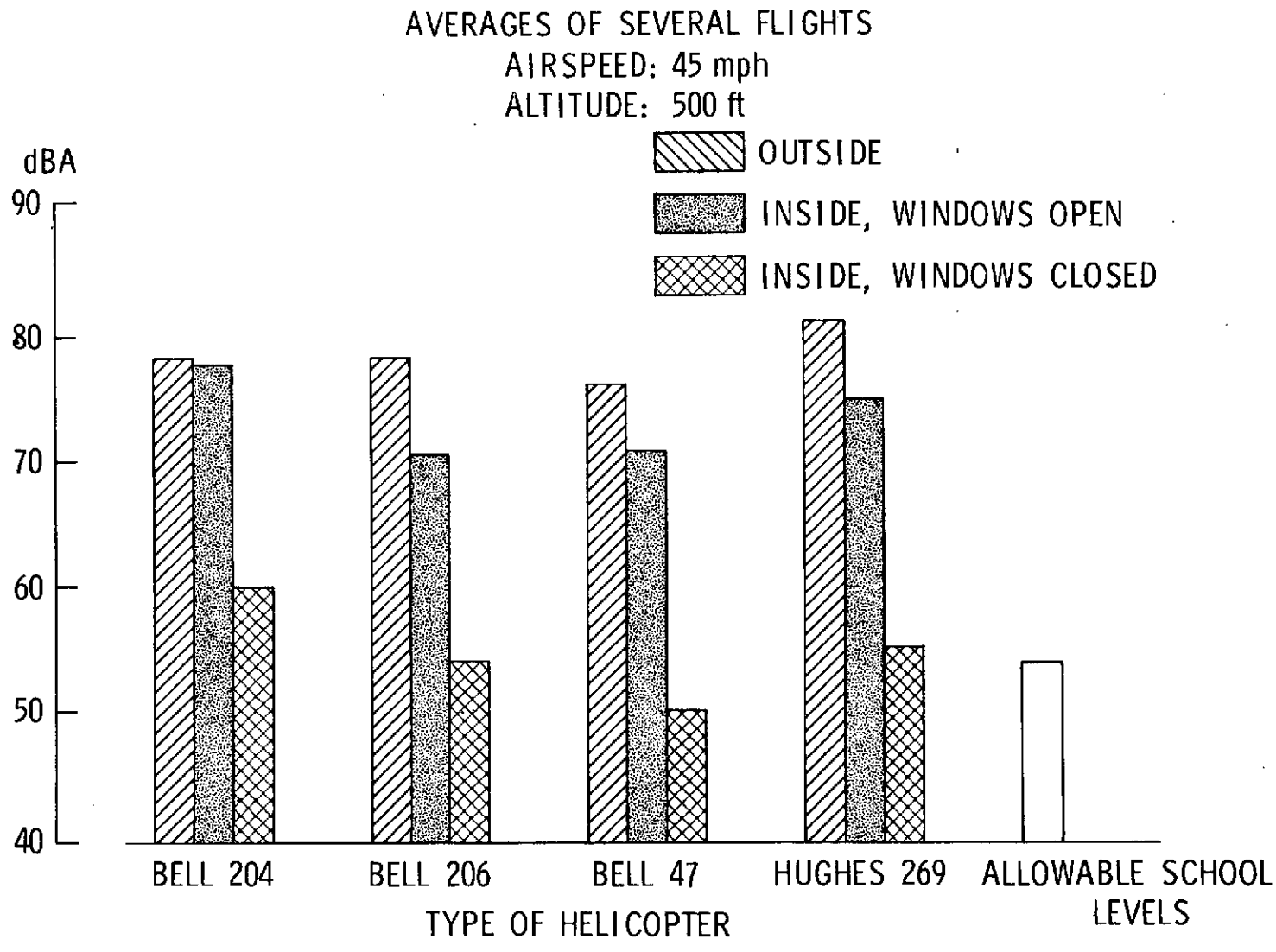

Figure 7.- Comparison of inside and outside dBA levels.

AIRSPEED: 45 mph, ALTITUDE: 500 ft

HELICOPTER	MICROPHONE LOCATION		OASPL	EPNL	dBA	PSIL
BELL 204	INSIDE					
		OPEN	92	93	77	65
		CLOSED	80	78	55	49
	OUTSIDE		96	100	78	74
BELL 206	INSIDE					
		OPEN	80	83	70	59
		CLOSED	71	70	55	42
	OUTSIDE		86	92	78	68
BELL 47	INSIDE					
		OPEN	80	83	70	59
		CLOSED	68	69	54	42
	OUTSIDE		86	94	77	69
HUGHES 269	INSIDE					
		OPEN	82	86	75	62
		CLOSED	70	71	59	45
	OUTSIDE		88	96	81	73

Figure 8. - Summary of various units as measured during the tests.

- MAXIMUM OUTSIDE dB(A) LEVELS WERE APPROXIMATELY THE SAME FOR ALL TEST HELICOPTERS
- FOR THE WINDOWS CLOSED CASE, SIGNIFICANT NOISE REDUCTIONS WERE NOTED AND THE dB(A) LEVELS WERE IN GENERAL AGREEMENT WITH ACCEPTED CLASS ROOM CRITERIA
- MEASURED INTERNAL dB(A) LEVELS WITH THE WINDOWS OPEN WERE SLIGHTLY LESS THAN OUTSIDE LEVELS BUT EXCEEDED PUBLISHED CLASS ROOM NOISE CRITERIA

Figure 9.- Concluding remarks.